

## DIFFUSION PROCESSES AND THEIR PATHS

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Recent confusion concerning extremal paths occurring in the functional integral approach to simple continuous Markov processes will be clarified by considering continuous and differentiable functions.

The functional integral representation of the propagator for a continuous Markov process  $\{x(t), t \geq 0\}$  may be written formally as:

$$P(x_f, t_f | x_i, t_i) dx_f = \int \mathcal{D}\{x(t)\} \exp[-S], \quad (1)$$

where we follow Feynman's notation [1], and where  $\mathcal{D}\{x(t)\}$  is a functional measure which need not be discussed explicitly here (see e.g. refs. [2-5]).

1. *The discrete action.* The lattice expression for the action  $S$  may be given as [3]<sup>1,2</sup>:

$$S = \tau \sum_{k=1}^N L_k, \quad (2)$$

$$L_k = \frac{1}{2c_2} \left[ \frac{x_k - x_{k-1}}{\tau} - \alpha c_1(x_k) - \beta c_1(x_{k-1}) \right]^2 + \alpha c'_1(x_{k-1}), \quad (3)$$

where the prime indicates differentiation with respect to  $x$ , where  $\alpha$  and  $\beta$  are arbitrary fractions such that  $\alpha + \beta = 1$ , and where ultimately the short time lapse  $\tau$  tends to zero ( $N\tau = t_f - t_i$ ). It is noted that there are in eq. (3) in fact three coefficients, which however

are interrelated due to the requirement that the propagator obeys the Fokker-Planck equation with drift function  $c_1(x)$  and constant diffusion coefficient  $c_2$ . In other words, the lagrangian  $L_k$  essentially belongs to a *stochastic* problem.

We now distinguish between two fundamentally different classes of paths associated with the above formulation.

(i) *The most-probable-transition-path.* This is the path (chain) of most probable successive small time ( $\tau$ ) transitions. Thus, this path has one fixed end point and one free end point. To derive its equation of motion we consider eqs. (1)-(3) with fixed  $x_{k-1}$  and determine the likeliest value of  $x_k$ . It is to be noted that here we only need *one* term from the sum over  $k$  in eq. (2). That is:

$$0 = \tau \partial L_k / \partial x_k = \frac{1}{c_2} \left[ \frac{x_k - x_{k-1}}{\tau} - \alpha c_1(x_k) - \beta c_1(x_{k-1}) \right] \times [1 - \alpha \tau c'_1(x_k)]. \quad (4)$$

We next let  $\tau \downarrow 0$  and consider those paths for which  $(x_k - x_{k-1})/\tau$  tends to a definite limit  $\dot{x}$ , that means we consider the subclass of *once differentiable functions*  $\{x(t)\}$ . Disregarding terms of order  $\tau$  one obtains:

$$(x_k - x_{k-1})/\tau = \alpha c_1(x_k) + \beta c_1(x_{k-1}) + O(\tau), \quad (5)$$

which, since  $\alpha + \beta = 1$ , thus leads to the *first order* differential equation:

<sup>1</sup> We have corrected for a few misprints in form. (2.18) of ref. [3].

<sup>2</sup> The last term in  $L_k$  may be partially specified at the post-point  $x_k$ , but - the corresponding term in  $S$  being of order  $\tau$  - this does not introduce anything new.

# Diffusion Processes And Their Sample Paths Flywingsore

**Ito**



## **Diffusion Processes And Their Sample Paths Flywingsore:**

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**Introduction to the Theory of Diffusion Processes** Nikolaï Vladimirovich Krylov, 1995 Focusing on one of the major branches of probability theory this book treats the large class of processes with continuous sample paths that possess the Markov property The exposition is based on the theory of stochastic analysis which uses such notions as stochastic differentials and stochastic integrals The diffusion processes discussed are interpreted as solutions of Itô's stochastic integral equations The book is designed as a self contained introduction requiring no background in the theory of probability or even in measure theory In particular the theory of local continuous martingales is covered without the introduction of the idea of conditional expectation Krylov covers such subjects as the Wiener process and its properties the theory of stochastic integrals stochastic differential equations and their relation to elliptic and parabolic partial differential equations Kolmogorov's equations and methods for proving the smoothness of probabilistic solutions of partial differential equations With many exercises and thought provoking problems this book would be an excellent text for a graduate course in diffusion processes and related subjects **Diffusion Processes and Their Sample Paths** Kiyosi Itô, Henry P. McKean, 1996 **Diffusion**

**Processes** Merkel Henry Jacobs, 1935 **Diffusion Processes and Their ...** Ito, 1974 *Diffusion Processes and Related Problems in Analysis, Volume I*, 1990 **Diffusion Processes with Reflection** Sebastian Andres, 2009-08

In recent years diffusion processes with reflection have been subject of active research in the field of probability theory and stochastic analysis where such reflected processes arise in quite various manners The present work deals with two rather different types of reflected diffusion processes In the first part we prove pathwise differentiability results for Skorohod SDEs with respect to the initial condition in particular we consider processes on convex polyhedrons with oblique reflection at the boundary as well as processes on bounded smooth domains with normal reflection In the second part a particle approximation of the Wasserstein diffusion is established where the approximating process can be interpreted as a system of interacting Bessel processes with small Bessel dimension More precisely we introduce a reversible particle system whose associated empirical measure process converges weakly to the Wasserstein diffusion in the high density limit Moreover we

prove regularity properties of the approximating system in particular Feller properties using tools from harmonic analysis on weighted Sobolev spaces      **Diffusion Processes and Related Topics in Biology** Luigi M. Ricciardi, 1977

*Multidimensional Diffusion Processes* Daniel W. Stroock, 2006      *One-dimensional Diffusion Processes and Their Boundaries* Inge S. Helland, Universitetet i Oslo. Matematisk institutt, 1996

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